Received Signal Strength Based Vertical Hand Off Scheme for K-Tier Heterogeneous Networks

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Abstract— **The k-tier heterogeneous wireless networks (kHWN) deployment focused on the needs of the users. Many challenges exist in integrating kHWN architectures into one seamless flow of voice, data and multimedia. The handoff's between kHWN that allows user equipment (UE) to continuously find seamless connectivity with the transceivers is complex and challenging to execute. The common and most desired, cost effective parameter for vertical handoff scheme (VHOS) is the receiving signal strength (RSS). This paper investigates the best suited empirical and statistical model based estimation to determine the RSS for GSM, UMTS, advanced Long Term Evolution (LTE) and WLAN integrated in the kHWN. Based on the statistics of the estimated RSS, the VHOS algorithm for kHWN is proposed. The simulation test has been conducted to validate the findings.**

Keywords-component; formatting; style; styling; insert (k-tier heterogeneous wireless network)

I. INTRODUCTION

The recent development in the wireless communication technologies continues to spread with the advancement of WLAN, LTE, and UMTS with existing GSM. The need of it from the user prospect is communication of voice, data, multimedia, video with an always connected mobility feature. The network prospect is to integrate each and every network to meet all the requirements. Hence the integrated solution is multitier and heterogeneous. In this paper k-tier heterogeneous wireless networks (kHWN) is considered [1]. The challenge is the interoperability with mobility in kHWN because of the co-existence of previous technologies such as GSM, UMTS etc. Each technology has its importance in terms of the cost effectiveness of the bandwidth, signaling load, access speed. The priorities must be set to make a trade-off between a satisfied customer and service cost of the network operator. So without mobility in the kHWN with a proper VHOS is not possible to access the kHWN.

Assuming the UE supports for all types of networks within the kHWN. The UE sends the measurement report based on the RSS through a common broadcast control channel in the physical layer of the each types of network in the kHWN. [2] The RSS is estimated through various pre-sets empirical and statistical models for a common terrain with certain model based RF signal loss reflected in the environment, Like Okumara-Hata model, which is widely-used. But as we are heading towards kHWN environments, we are certainly using different frequency bands with different technologies all together. So we should have certain robust model considering more local terrain and environmental conditions.

In the literature survey for estimating the RSS for kHWN some standard methods like Okumara Hata model and few literatures followed Walfisch-Ikegami models were used [3]. The major disadvantages of such propagation models are; these are not suited for each and every type of terrain and the environment for estimating the path loss [9]-[12]. The RSS is solely depends on the proper estimation of path loss for which a proper path loss model is needed to adopt. Also the RSS hugely depends on pre-set environmental information. In this paper we selected the best suited empirical and statistical model with the prior information of Indian urban as well as sub-urban environments. Thus separate path loss propagation models are proposed for each tier of the network. The statistical model aligns in accordance to the measured data, considering roof height, road width as normal random variables. The Five parameters are modeled statistically, with the dependencies on height of base station, distance from base station, road width and roof top height. The model is validated by comparing the simulated results with the measurement campaigns carried out in urban and suburban regions [10]-[11]. From the path loss model the RSS has been estimated for better performance.

The hand off in wireless communications are proposed mainly based on the parameters of RSS, signal to noise ratio (SNR), interference and bit error rate [11]-[13]. A number of VHOS are studied where the scheme proposed VHOS between either of two networks [1]-[3] taking various methods of complexity. In this paper we propose the VHOS between each tier of the network, after getting the proficiency and accuracy in the RSS measurement in each network of the kHWN domain.

The paper is organized as follows. The optimized empirical path loss models suited for kHWN environment is discussed Section-II. The analysis of RSS with varying distance is also explained in section-II. Section-III deals with the simulation results of the proposed method. The process of VHOs is demonstrated in Section-IV. The conclusion, performance and feasibility of VHOs in k-tier networks are outlined in Section V.

II. RSS MEASUREMENTS USING EMPERICAL PROPAGATION MODELS

Here the scenarios of kHWN from femto cell to macro cell are taken into account, where access point (AP) of each tier has the different receiving power throughout the entire access domain. The 1st and 2nd tiers considered are GSM, UMTS micro cell and LTE, Pico cell respectively. The third tier is WLAN for femto cell. The entire coverage is assumed to be k-tier providing uniform coverage with different transmitting and receiving powers.

Several statistical and empirical propagation loss models are provided in the literature [4]-[6]. These propagation models are based on extensive experimental and statistical data in various environments for urban and suburban environments. The parameters used in the propagation models are the path loss and RSS. The UE compatible with all the k-tier Network types is considered starting from GSM to LTE.

The performance of VHOS in a kHWN depends mostly on RSS between the UEs and transceiver nodes (TNs). The RSS along each direction accounts the power present in the received signal. Thus the RSS must be strong enough between the TNs and UEs to maintain the performance. In the next subsection different RSS estimations are done for GSM, UMTS, LTE, WiMAX and WLAN networks.

A. GSM AND UMTS NETWORK

Assume that the GSM and UMTS cellular networks are deployed as micro cells within the half a kilometer. The licensed frequency bands for GSM/UMTS in the Indian sub-urban environment are 900 MHz, 1800 MHz and 1900 MHz band. So considering the micro cell as first of the k-tier of wireless network spread for Indian sub-urban and urban areas the path loss in dB based on the COST 231 Walfisch-Ikegami propagation model, [6] which is an extension to the Hata-Okumura model that has correction for environment based on combination of models from J. Walfisch and F.Ikegami model, based on numerous site tests and analysis. It is appropriate for flat suburban and urban areas that have consistent building heights, and large population areas with densely locate buildings such that the cell radius can be less than 1 km [7]. It calculates the multiple screen forward diffraction loss of base station antenna. This gives a better path loss prediction.

$$P_L = 59.86 + 20\log(d) + 20\log(f) - 10\log(w) + 10\log(f) + 20\log(h\_roof - h\_UE) - 18(1 + (h\_TX - h\_roof)) + (h\_TX - h\_roof) + 18\log(d) - [4 + 0.7(f/925 - 1)]\ \log(f) - 9\log(b)) \qquad (1)$$

where P_L is the path loss in dB, d is the distance between UE and the Transceiver in Km, *f* is the frequency in MHz, *w* is the mean value for width of the street in meters, h_{roof} is the mean value of height of the buildings in meters, h_{UE} is the height of the UE in meters, h_{TX} is the height of the transceiver in meters, *b* is the mean value of building separation in meters. The RSS for GSM micro cell in the kHWN is expressed in dBm as

$$RSS_{GSM/UMTS} = P_{TX} + \sum G_T - \sum A - P_L \qquad (2)$$

Where the RSS of GSM/UMTS expressed dBm, the transmitted power of the transceiver, G_T is the antenna gain in dB, *A* is the loss of RF connectors at the transceiver end.

B. WIRELESS LOCAL AREA NETWORK

In the kHWN, WLAN has an important application for in-building solutions by deploying as femto cells. Integration of femto cells in a kHWN like WLAN system possess the biggest design challenges, As its difficult to predict the propagation of radio wave in an indoor environment. In the 802.11 WLAN work group with the 2.5 GHz frequency band, characterization of the indoor radio propagation channel is essential. The empirical model helps to reduce the computational complexity [9]. So we have taken Log Normal path loss model, which is best, suited for femto cell range with 2.5 GHz frequency range.

The path loss for WLAN (PL_{WLAN}) in dB can be expressed as

$$PL_{WLAN} = PL(d_0) + 10nlog\left(\frac{d}{d_0}\right) + X_\sigma \qquad (3)$$

Where $PL(d_0)$ is the path loss w.r.t the reference distance d_0 'n' is the path loss exponent, d is the separation between transceiver and UEs in meter. X_σ is a zero mean Gaussian distributed random variable with standard deviation σ . The reference distance d_0 , the path loss exponent n and the standard deviation 'σ', statistically describes the path loss for an arbitrary distance between transceiver and UE.

The received signal strength(RSS_{WLAN}) in dBm, according to the path loss can be estimated.

$$RSS_{WLAN} = P_{TR} - PL_{WLAN} \qquad (4)$$

The P_{TR} is the actual transmitted power by the Transceiver station, in dBm. The VHO takes place when the RSS obtains above a certain interference sensitivity level.

C. LTE ADVANCED NETWORK

LTE Advanced is a mobile communication standard, formally submitted as a candidate of 4G system to International Telecom Union(ITU) in 2009 and accepted in march 2011[7][8]. This is standardized by the 3rd generation partnership project (3GPP). One of the important advantages of LTE Advanced is the ability of advanced network optimization for kHWN with a mix of macro cells with low power Pico cells and femto cells. The Pico cell range varies up to 200 meters and the femto cell coverage range extends up to 12 meters. The path loss in dB is estimated by the most commonly used Advanced Okumara and Hata Empirical model [12].

$$PL_{LTE} = 69.55 + 26.16log(f) - 13.82\log(h_{TX}) - C_H + [44.9 - 6.55\log(h_{UE})]\log(d) \quad (5)$$

For sub urban and urban areas in India

$$C_H = 0.8 + (1.1\log(f) - 0.7)h_{UE} - 1.56\log(f) \quad (6)$$

C_H is the antenna height correction factor in dB. The RSS for advanced LTE is evaluated in dBm as

$$RSS_{LTE} = P_{TX} + G_T + G_{RX} - PL_{LTE} - A \quad (7)$$

Where G_{RX} is the gain of the receiver in dB.

III. SIMULATION RESULT AND PERFORMANCE ANALYSIS

The parameters for simulation are presented, considering the urban and sub urban terrain of India. In Table-1 shows the network parameters.

Table 1 Network parameters details

Network Type	Tran-sceiver output Power	Frequency Band	Gain of the TX Antenna	Gain of UE's Antenna	Duplex-er RF connector loss	RSS Thres-hold
GSM	-45dBm	900 MHz	15dB	1 dB	2 dB	-115dBm
UMTS	-43dBm	1900 MHz	17dB	2 dB	1.5 dB	-100dBm
WLAN	-47dBm	2500 MHz	18dB	4 dB	0.55 dB	-90dBm
LTE	-23dBm	2400 MHz	14dB	3 dB	0.45 dB	-80dBm

Table-2 shows the environmental and path loss parameters of kHWN. The performance of path loss and RSS of kHWN is calculated from the simulation result. The RSS threshold for different Networks in each tier is estimated in Table-1.

Table 2 Terrain and environmental data

Parameters	Values
Average Height of the Transceivers GSM, UMTS,WLAN, LTE Networks	45,40, 25, 30Mtrs
Average height of the Receiver UE	2.5Mtrs
Mean Height of the Buildings	12Mtrs
Mean width of the Road	6Mtrs
Mean Separation of Buildings	8Mtrs
Duplexer and connector loss	2dB
Path loss exponent for urban/ sub-urban areas	1.92
WLAN reference distance (30mtrs) mean path loss	49.76dB

The simulation results given in Figs.1, 3, and 5 show for the path loss of GSM, UMTS, WLAN and LTE Networks. The path loss for GSM varies from 105 to 165 dBm with a distance of 0.5 Km with the terrain data collected and estimated, while for UMTS it varies from 120 to 180 dBm. The plot is shown in Fig.1.

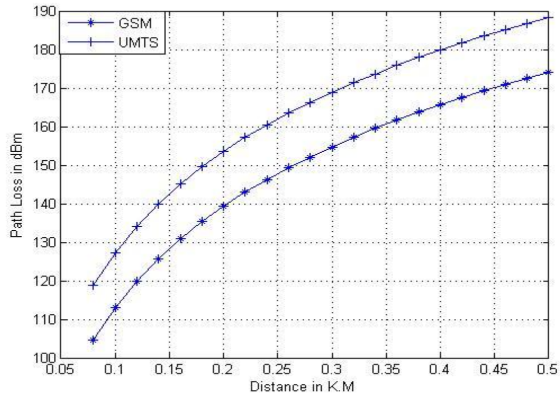

Figure 1 Path loss simulation for GSM/LTE Network

From the path loss model the RSS is estimated and simulated from the same statistical data based on the path loss model as discussed earlier. From the simulation the RSS for GSM varies from -35dBm to 95dBm for a distance of 0.5 Km and for UMTS the RSS varies from -20 to -95 dBm. As shown in simulation plot in Fig-2.

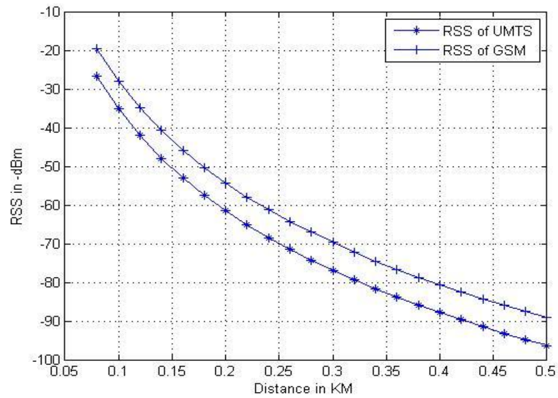

Figure 2 The RSS simulation for GSM and UMTS network

Similarly the path loss plot for WLAN is simulated from the data provided in Table-1 and 2. The simulation is based on equation (6). The path loss varies from 30 to 105 dB and the RSS is estimated from the statistical and empirical model and data as discussed earlier in section-II, B. From the simulation result it shows the RSS varies from -20 to 85 dBm for a distance of 0.5 Km in the terrain of Indian urban and sub urban areas. The simulation plot is shown in Figs. 3 and 4 respectively.

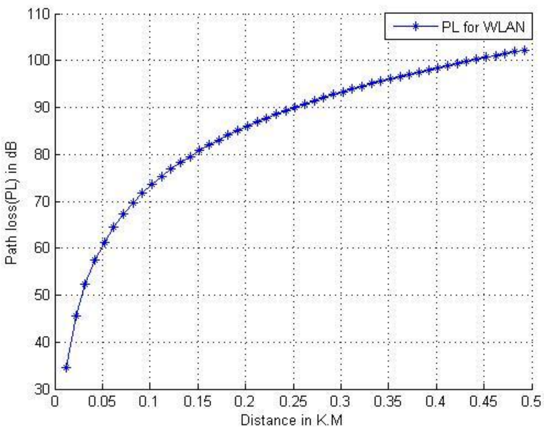

Figure 3 Path loss simulation of WLAN Network

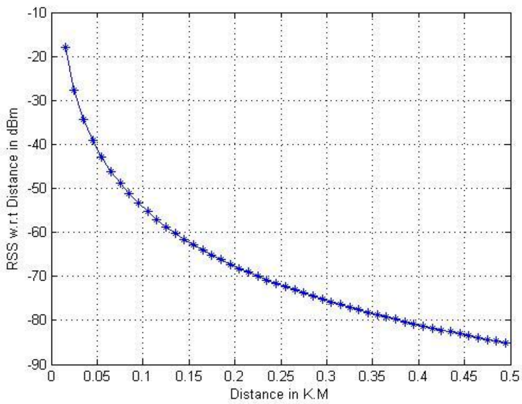

Figure 4 Simulations of RSS for WLAN Network

For LTE the path loss and RSS simulation is shown below in Fig-5 and Fig-6

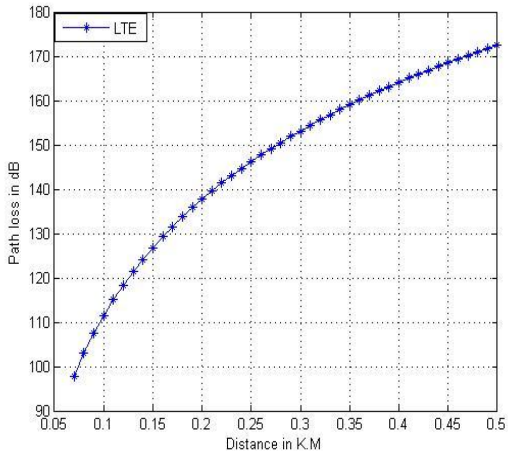

Figure 5 Path loss simulation of LTE Network

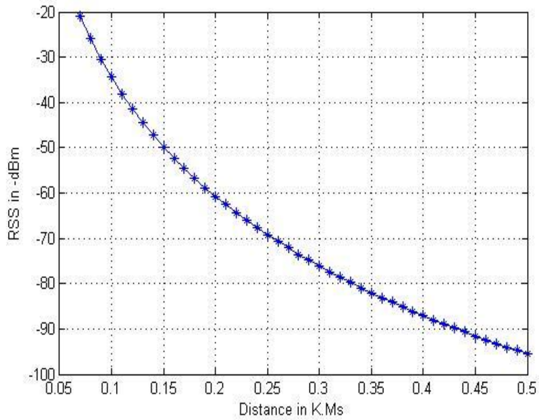

Figure 6 Simulations of RSS for LTE Network

The comparison of the RSS for each tier of the Network simulation is as shown in Fig-7

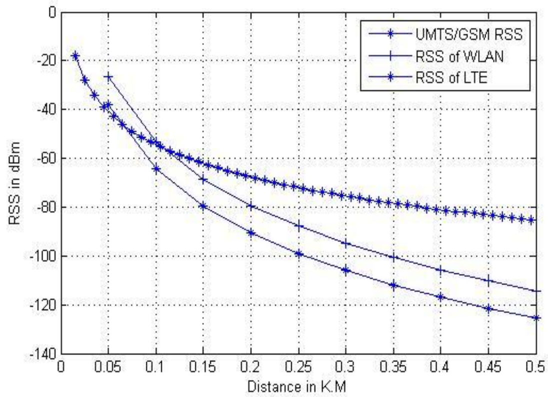

Figure 7 RSS comparisons for UMTS/GSM/WLAN& LTE & NETWORKS

IV. VHO SCHEME

In the kHWN, the accessibility of the UEs can be dedicated for voice and data. The voice call is preferred in circuit switched (CS) domain of networks, GSM and UMTS and the packet switched (PS) networks, LTE and WLAN considering the bandwidth and signaling cost into account. The UE's send measurement reports of RSS for all the adjacent Transceivers in the k-tier heterogeneous network through the broadcast control channels (BCCH) [14]. When a call is initiated the UE measures the current RSS of the networks. The algorithm for the VHO is proposed below:

// VHOS for Voice call

1: If $R_G < R_{thGSM} + h_V$ *and* $R_U \geq R_{thUMTS} + h_V$

Then the handoff is done from GSM to UMTS

2: If $R_U \leq R_{thUMTS} + h_V$ **and** $R_G > R_{thGSM} + h_V$

Then the Handoff is done from UMTS to GSM

// VHOS for Data call

1: If $R_W < R_{thWLAN} + h_D$ *and* $R_L \geq R_{thLTE} + h_D$

Then the handoff is done from LTE to WLAN

2: If $R_L \leq R_{thLTE} + h_D$ and $R_W > R_{thWLAN} + h_D$

The R_{GSM}, R_{UMTS}, R_{LTE}, R_{WLAN} are the current RSS of the GSM, UMTS, LTE and WLAN networks at a reference point 'p' respectively. The threshold set for GSM, UMTS, LTE, WLAN are $Rth_{GSM}, Rth_{UMTS}, Rth_{LTE}, Rth_{WLAN}$ respectively. These are the threshold RSS values set for each network, beyond this the call gets transfer to another network or the same network considering the measurement report and type of access, voice and data. But considering only the threshold values causes' ping pong handoff and that increases the signaling load of the entire network. So the hysteresis values set to avoid the problem. The hysteresis for voice call is h_V and for data is h_D.

V. CONCLUSION

In this paper we estimated the path loss and RSS for all the k-HWN separately considering the Indian terrain conditions for urban/ sub urban environments which give the best result. Then the algorithm for vertical hand off techniques proposed which integrates the network types like GSM, UMTS, LTE, and WLAN in the kHWN. The importance of VHOS is dealing with old technologies like GSM, as well as to club with the existing and new technologies we need interoperability of both using the VHOS. This paper mainly drives the idea of taking the RSS parameters of the kHWN, from novel statistical and empirical models, which suits for Indian Urban/sub-urban terrains for setting the algorithm of VHOS. The proposal of VHOS algorithm is robust and noncomplex as the real-time parameters for estimating RSS is pre-set according to Indian terrain can be modified to other known terrain also.

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